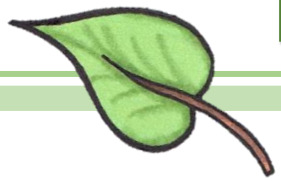
The world in 50 years from now

Lesson guide



By Sanne Schouten

How to use this guide

Goal and target group

This lesson is suitable for students in secondary education, who are 13 to 16 years old. This lesson serves to draw the attention of these young students to Biobased thinking and introducing them to a Biobased Economy.

A block of normal black text with a green heather explains a part of the lesson.

A light green box represents a suggestion. With these suggestions the lesson can be adapted to different students or to a different amount of time available.

Suggestion 4.

You can first ask the students if they know any applications. They can write them down in their workbook.

Summer 2069

Thomas looks out the window and sighs, another day of school. “Thomas, you must really hurry now, otherwise you’ll be late for school”, says his mother. “Yes ma”. School is a nice distraction from reality lately. The journey to school however, is a disaster. Since there’s no more gasoline, he has to cycle to school every day, a two-hour journey. In grandpa’s time it was healthy to cycle. Nowadays, you have to wear a mouth cap the minute you step outside Also, he is so tired lately. With the food ration the government has determined, he and his classmates hardly have the energy to focus at…

A block of dark green text is text that can be directly used to explain or to illustrate a part of the lesson for the students.

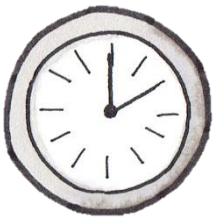
A light-yellow box represents explanation of specific slides in the PowerPoint. Also, the number of the slide belonging to a piece of explanation is displayed in a light-yellow box with a green leaf.

The PowerPoint slide shows a flow scheme of our economy at the moment. It is a linear scheme. Fossil fuels are used for practically everything we do and make, and the amount of waste gets more and more.

The workbook contains the illustrations and space to write down the worlds’ problems.

A light red box represents explanation of the workbook that belongs with the lesson.

A clock represents the time needed for a certain part of the lesson.



Introduction

Goal and target group

This lesson is created in the context of the Think Biobased Challenge. The lesson is suitable for students in secondary education, who are 13 to 16 years old. This lesson serves to draw the attention of these young students to Biobased thinking and introducing them to a Biobased Economy.

How to offer this lesson

This lesson can be offered in a normal chemistry classroom with lab tables and a possibility to show a PowerPoint presentation. This guide comes with a PowerPoint presentation and a workbook for the students. The lesson is suitable for classes of 45 to 60 minutes. It depends on how much time is spent on each part of the lesson, how long the total lesson will take. For each part of the lesson, a time indication is added in this guide.

Suggestion 1.

When printing a workbook in colour for all the students is too expensive, it is sufficient to just print out the protocol of the experiment. In this case, just let the students write down the questions asked and the observations of the experiment in their own notebook.

Suggestion 2.

When no chemistry classroom is available, the experiment can be executed with normal household material. More about this suggestion can be read in suggestion 8 at page 9.

Part 1 – creating awareness

15-18 minutes

At the beginning of the lesson the workbooks can be handed out to the students and the PowerPoint presentation can be started. After the introducing slide, the PowerPoint shows an illustration of the world in 50 years from now, if we don't change anything in our way of life. The story below can be read to the students while showing this illustration.

Story negative world Nr. 2

Summer 2069

Thomas looks out the window and sighs, another day of school. "Thomas, you must really hurry now, otherwise you'll be late for school", says his mother. "Yes ma". School is a nice distraction from reality lately. The journey to school however, is a disaster. Since there's no more gasoline, he has to cycle to school every day, a two-hour journey. In grandpa's time it was healthy to cycle. Nowadays, you have to wear a mouth cap the minute you step outside Also, he is so tired lately. With the food ration the government has determined, he and his classmates hardly have the energy to focus at school, after a two-hour journey per bike. But there's nothing that can be done about it, since there's not enough food anymore to feed everyone. Another problem is the summer temperatures, not healthy anymore. And there's always the fear that the water will come and that half of the county will no longer be land. He doesn't even want to think about where all these people, that live there, must go then. Sometimes his mother tells that they would go to the beach and swim in the sea when she was little. He is not able to imagine that, as the water nowadays is not even safe to swim in, with all that plastic and other garbage. "Thomas, are you sleeping or what? You are going to be late!".

After that, the PowerPoint presentation shows an illustration of the world in 50 years from now, if we change our economy to a Biobased economy. The story below belongs to this illustration.

Story positive world Nr. 3

Summer 2069

Emma leans back in her lawn chair; the weather is lovely this morning. "Emma, hurry, otherwise you'll miss the bus!", says her mother. "Yes ma!". Emma sighs, another day of school today. But she has something to look forward to today. Tonight, they are celebrating grandpa's 65th birthday. They will be dining in the new restaurant. They serve delicious fried grasshoppers with bacon-seaweed, at least, according to her friend. She always loves spending time with her grandparents. Sometimes they tell about the time they were Emma's age. Can you imagine they ate animals like cows? Grandpa has finally bought a new car, the most modern sort of its kind. It can drive on garbage! "Emma, you must really hurry now! You promised you would bring the plastic bottles of our party yesterday to the compost container." Well, it will soon enough be evening fast enough. And maybe she can go to the beach this afternoon with her friends, the water will have a lovely temperature by now.

Class discussion Nr. 4

The next part of this lesson is a class discussion about the illustrations shown before. This part serves to make the students really familiar with the problems in the world we have to solve.

With a group of students in the age of 13 or 14: let them discuss the illustrations and the stories with the whole group. Ask them the question what they think the worlds' problems are according to the illustrations. With a group of students in the age of 15 or 16: let them discuss the illustrations in groups of four students. Let them write down the worlds' problems in the workbook. Afterwards, discuss shortly what problems the different groups have found.

The workbook contains the illustrations and space to write down the worlds' problems.

Suggestion 3.

If the discussion doesn't get going or stops, help the students a little. Ask them what they see in the illustrations in certain parts. An explanation of these different parts in included below.

Explanation of the illustrations in the PowerPoint slides

Plastic soup
The plastic in the sea describes the plastic soup. The oceans are full of plastic, which fall apart in microscopic particles. These particles are ingested by sea creatures. Or, sea creatures get stuck in large pieces of plastic. But, one way or another, many will die. In the positive illustration the plastic that is used is compostable.

Warming of the earth
The thermometer describes the warming of the earth. The water almost being higher than the dune is a result from this warming of the earth. As the ice on the poles melt, the water level rises. (global warming)

Enhanced greenhouse effect
The smog in the sky and the industry buildings describe the current amount of exhaust gasses that are emitted and that contribute to the enhanced greenhouse effect. In the positive illustration there are no exhaust gases anymore, the sky is blue and the sun is shining. Lots of birds fly in the sky.

Fossil fuels
The price board from the gas station describes that fossil fuels are not inexhaustible and that there will once be no more. In the positive illustration can be seen that the exhaust fumes from cars do no longer influence the greenhouse effect. They can, for example, be driving on biomass (like the inedible part of corn stalks). More information about biomass is given in the next part of the lesson: What is a Biobased economy?

Food shortage
The highly guarded carrots describe that the earth population is growing and that we have to find other, more efficient ways of providing all these people with food. Otherwise, we will not have enough. In the positive illustration other food sources are found, such as insects.

Part 2– What is a Biobased economy?

 10 -12 minutes

Now that we have identified the world's problems, we need to think of solutions. This lesson is about developing a Biobased economy. In this part of the lesson the definition Biobased economy is explained. Use the explanation below to explain this definition to the students.

What is a Biobased economy?

Our economy at the moment Nr. 6

Our economy at the moment relies mostly on fossil fuels. Fossil fuels are fuels formed from dead plants and animals under high pressure and temperature in the Earth's crust. It takes millions of years to form these fuels. Examples of fossil fuels are oil, coal and natural gas. (Science Daily, n.d.) Fossil fuels are used to make practically everything we need in our modern society, such as plastics, medicine, electronics, energy and even to produce food. But fossil fuels are non-renewable, unsustainable, resources. As they take millions of years to make and we use it in such large quantities. The waste products can also not be degraded easily and can only be re-used in a limited amount. Moreover, the carbon dioxide that is produced while processing the fossil fuels, enters the air. As it takes millions of years to form new fossil fuels, that are made from plants that have taken up this carbon dioxide, the carbon dioxide accumulates in the air. Thus, it contributes to the enhanced greenhouse effect. So, in short, our economy relies on fossil fuels, which are not renewable or sustainable and have a bad influence on the environment.

The PowerPoint slide shows a flow scheme of our economy at the moment. It is a linear scheme. Fossil fuels are used for practically everything we do and make, and the amount of waste gets more and more.

Sustainability Nr. 7

This doesn't sound good, does it? We have to take care of our world, otherwise our children, grandchildren and so on, won't have a nice earth to live on. This is what sustainability means: we must provide for our own needs (such as food and clothes), but we must thereby make sure the future generations can do that too.

A Biobased economy Nr. 8

A Biobased economy doesn't rely on fossil fuels anymore, but on biomass. Biomass is material form plants and animals. Plants, for example, are made of the same building blocks as fossil fuels (carbon and hydrogen) and can therefore also be used to produce the things we need. The advantage of using plants is that they grow fast. So, they can be produced fast and over and over again. Another advantage of plants, is that they use carbon dioxide to make oxygen and glucose (which is their energy resource), this is called photosynthesis. One square metre of plants consumes just as much carbon dioxide as the amount of carbon dioxide that is produced when processing one square metre of plants. So, using plants does not enhance the greenhouse effect. Plants are thus a renewable, sustainable resource. The waste products of processing plants can be used again or can be degraded easily to for example form compost. So, nothing is wasted and plants will never run out.

The PowerPoint slide shows a flow scheme of a Biobased economy. The loops are now closed. Waste does not accumulate, as it can be degraded to compost or used again to make other products.

Applications of a Biobased economy

So, biomass is the way to go. But how to use this biomass exactly? In this part follow a few examples of applications of a Biobased economy.

Suggestion 4.

You can first ask the students if they know any applications. They can write them down in their workbook.

Suggestion 5.

You can discuss the applications below with the students. Do they think these are good solutions for the world's problems identified earlier?

Eating insects Nr. 9

The first example is using the biomass of insects as a food source. Grasshoppers and mealworms for example contain a lot of proteins and are therefore very nutritious. But, why are insects a better option than cows? Insects do not need a large amount of space to be grown, they grow very fast and they do not produce methane farts as do cows. Methane farts have enhancing effect on the enhanced greenhouse effect. So, insects are a better option.

Plastic from potatoes Nr. 10

Plastic as we know it now, is mostly made of fossil fuels. But it can also be made out of any biomass that contains natural polymers. Polymers are very large molecules that which are essentially a lot of the same small molecule linked together to form a large chain. Potatoes, for example, contain starch. Starch is an example of a natural polymer. When starch from potatoes is heated, the rolled-up starch is now neatly ordered in a network. In this network the chains stick to each other. This network of polymer chains is essentially plastic. Since normal potato skins and waste can be thrown in the compost bin, this plastic is also compostable. The only issue with this type of solutions, is that we use food to produce other products we need. So, this is something to consider.

Bio-ethanol

Another solution is bio-ethanol. This is an alternative for driving of fossil fuels. Bio-ethanol is produced by fermenting sugar (which is glucose) from corn, rapeseed, sugar beets and many more natural products, so that is forms alcohol. But this solution also competes with food producing. (Ikleefgroen.nl, 2010)

Seaweed Nr. 11

Seaweed does not cover only one problem, but a lot.

In the PowerPoint a slide a lot of these applications are shown (it can be used as food, to produce bio-ethanol, plastic, etc). The focus of the rest of this lesson is on seaweed.

Part 3– Let's test it!

20 - 30 minutes

This is the experimental part of the lesson. In this part of the lesson the students can experiment with a Biobased food source, seaweed.

The experiment

Nr. 13

The goal of the experiment, is to involve the students in the research of finding a Biobased food source. The students will get some seaweed. They will taste it just how it is, out of the sea. They will taste it when cooked in water and they will taste it when it is fried in (olive) oil. They will find the normal and cooked seaweed not very nice to eat, but the fried seaweed will taste like bacon. The protocol with space to write down observations is included in the workbook. The class can be divided in groups of four students.

In the workbook the students have to write down how the differently prepared seaweed looks and how it tastes. They also have to write their opinion about seaweed as a Biobased solution.

Suggestion 6.

After the experiment you can discuss the observations of the students. Did they come up with the bacon flavour? Why do they think this is a good solution, or why not?

Materials and equipment per group

- ✓ Three strips of seaweed (available at https://seamorefood.com/)
- ✓ 200 ml of bottled water
- ✓ 50-75 ml of olive oil (enough to cover the bottom of the beaker)

- ✓ 400 ml beaker (this beaker may not have been used in other experiments, for safety reasons)
- ✓ Burner with tripod and gauze or heating jacket with standard and clamps
- ✓ Thermometer
- ✓ Fork (or anything to take the hot seaweed out of the water or oil
- ✓ Paper towels
- ✓ Timer

Suggestion 7.

When olive oil is too expensive, other oils such as sunflower oil can also be used.

Suggestion 8.

When no glassware of no special classroom is available, you can use a normal frying pan and cooking pan to fry and cook the seaweed. In this case, it is probably more practical to do the experiment as a demo-practical. Just use more seaweed at the same time, so everyone can taste.

Procedure

Before the students start the experiment, they must put on a lab coat and a pair of safety glasses. When their hair is long, they should tie it in a ponytail or a bun.

Plain seaweed

Taste a strip of seaweed just as it is and fill in the observation form for this step.

Cooked seaweed

Fill the beaker with 200 ml water and heat the water with the burner or the heating jacket, until the water reaches 100 ^{o}C or 212 ^{o}F (use the thermometer). Then, place a strip of seaweed in the boiling water, be careful the water is hot. Cook the seaweed for about 40 seconds. Turn off the burner or heating jacket and remove the seaweed from the water with the fork. Let the seaweed cool down on a paper towel. Now, taste the cooked seaweed and fill in the observation form for this step.

Fried seaweed

Remove the water from the beaker, and dry the beaker. Make sure it is really dry, otherwise the oil will later on splash a lot, which is dangerous.

Fill the beaker with 50-75 ml of oil, or until the bottom of the beaker is covered. Heat the oil with the burner or the heating jacket until the temperatures reaches approximately 150 ^{o}C or 300 ^{o}F. Then place a strip of seaweed in the hot oil, be careful it is very hot and it can splash. Fry the seaweed approximately 10-20 seconds on each side. Use the fork to turn the seaweed. After both sides have been fried, turn off the burner or heating jacket and remove the seaweed from the oil with the fork. Let the seaweed cool down on a paper towel. Lastly, taste the fried seaweed and fill in the observation form for this step.

Cleaning up

Collect the oil back into the original packaging and discard it according to the local environmental regulations. Your teacher will tell you how to do this. Clean the glassware and the fork with soap and throw away the paper towels.

Maillard reaction

Nr. 14

This part of the lesson explains in simple words the chemistry behind the experiment described above. It depends on the amount of knowledge the students already have; what kind of explanation can be used. Below is a simplified version and a slightly more difficult one.

The PowerPoint slide shows the reaction mechanism in illustrations.

Simplified explanation

What makes fried food, in this case fried seaweed, tastier than unfried food? Well, the Maillard reaction is usually responsible for that. The Maillard reaction can even take place at room temperature, but it happens really slow and with very few molecules. At a temperature of 140-165 ^{o}C or 284-329 ^{o}F the reaction takes place the fastest. That's exactly the temperature of the oil of our experiment! The Maillard reaction has a few steps. First, sugar (in the food) and an amino acid (the building block of proteins) react to form an intermediate molecule. A bond between two atoms in this molecule is moved to other atoms, the molecule that is formed now is called the Amadori compound. This Amadori product can react with all sorts of other present molecules to form new molecules which have a certain taste or give the food its brown colour.

More difficult explanation

What makes fried food, in this case fried seaweed, tastier than unfried food. Well, the Maillard reaction is usually responsible for that. The Maillard reaction can even take place at room temperature, but it happens really slow and to very few molecules. At a temperature of 140-165 ^{o}C or 284-329 ^{o}F the reaction takes place the fastest. That's exactly the temperature of the oil of our experiment! The Maillard reaction has a few steps. First, the carbonyl group of sugar from the food (the carbon bonded to oxygen with a double bond) and the amino group (the nitrogen atom attached to the rest of the amino acid) of an amino acid (the building block of proteins) react to form an intermediate molecule. The amino group is now attached to the carbon which previously had the oxygen. The double bond between this carbon and the nitrogen is moved to another oxygen of the sugar. The molecule that is formed now is called the Amadori compound. This Amadori can react with all sorts of other present molecules to form new molecules which have a certain taste or give the food its brown colour.

(Compound Interest, 2015)

Resources

Compound Interest. (2015, May 3). Food Chemistry – The Maillard Reaction | Compound Interest. Retrieved January 21, 2019, from https://www.compoundchem.com/2015/01/27/maillardreaction/

Ikleefgroen.nl. (2010). Bio ethanol. Retrieved January 21, 2019, from http://www.ikleefgroen.nl/energie/bio-ethanol/+/

Ilyashov, A. (2018, September 10). How (and Why) to Cook With Bugs, According to Three Chefs. Retrieved January 18, 2019, from https://www.nytimes.com/2018/09/10/t-magazine/bug-insects-recipes.html

Klaassen, M. (2016). *Introduction to the Biobased Economy*. Retrieved from https://maken.wikiwijs.nl/51426

Science Daily. (n.d.). Fossil fuel. Retrieved December 30, 2018, from https://www.sciencedaily.com/terms/fossil_fuel.htm

While making this Biobased lesson I was assisted by the Marine Biobased Specialties Research Group at the HZ University of Applied Sciences, in particular by Tanja Moerdijk.

All the illustrations and pictures in the guide, workbook and PowerPoint presentation (except for the pictures of the insects and the seaweed in the PowerPoint) are drawn by hand.

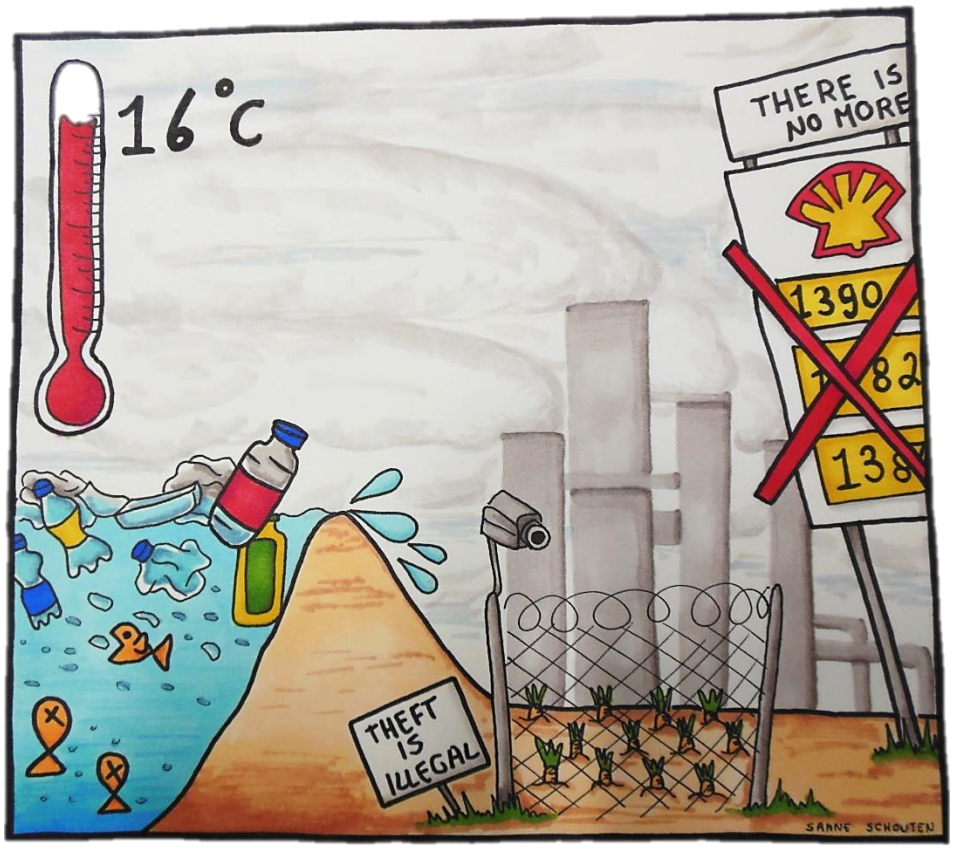
The world in 50 years from now

Workbook

Name:

Class discussion

The world in 50 years from now if we do nothing



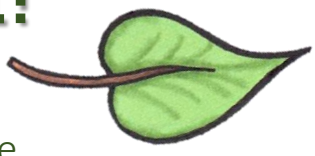
The world in 50 years from now in a Biobased economy

What worlds' problems do you see in these illustrations?

Biobased applications

What applications of a Biobased economy can you think of? And what problems do they solve?

Let's test it!



The experiment - finding a Biobased food source

Materials and equipment

- ✓ Three strips of seaweed
- ✓ 200 ml of bottled water
- ✓ 50-75 ml of oil (enough to cover the bottom of the beaker)

- ✓ 400 ml beaker
- ✓ Burner with tripod and gauze or heating jacket with standard and clamps
- ✓ Thermometer
- ✓ Fork (or anything to take the hot seaweed out of the water or oil
- ✓ Paper towels
- ✓ Timer

Procedure

Before you start the experiment, put on a lab coat and a pair of safety glasses. When your hair is long, you should tie it in a ponytail or a bun. Now, you are ready to start!

Plain seaweed

Taste a strip of seaweed just as it is and fill in the observation form for this step.

Cooked seaweed

Fill the beaker with 200 ml water and heat the water with the burner or the heating jacket, until the water reaches 100 ^{o}C or 212 ^{o}F (use the thermometer). Then, place a strip of seaweed in the boiling water, be careful the water is hot. Cook the seaweed for about 40 seconds. Turn off the burner or heating jacket and remove the seaweed from the water with the fork. Let the seaweed cool down on a paper towel. Now, taste the cooked seaweed and fill in the observation form for this step.

Fried seaweed

Remove the water from the beaker, and dry the beaker. Make sure it is really dry, otherwise the oil will later on splash a lot, which is dangerous.

Fill the beaker with 50-75 ml of oil, or until the bottom of the beaker is covered. Heat the oil with the burner or the heating jacket until the temperatures reaches approximately 150 ^{o}C or 300 ^{o}F. Then place a strip of seaweed in the hot oil, be careful it is very hot and it can splash. Fry the seaweed approximately 10-20 seconds on each side. Use the fork to turn the seaweed. After both sides have been fried, turn off the burner or heating jacket and remove the seaweed from the oil with the fork. Let the seaweed cool down on a paper towel. Lastly, taste the fried seaweed and fill in the observation form for this step.

Cleaning up

Collect the oil back into the original packaging and discard it according to the local environmental regulations. Your teacher will tell you how to do this. Clean the glassware and the fork with soap and throw away the paper towels.

Observation forms

Plain seaweed

Describe how the seaweed looks. Consider shape, colour, etc.

Describe how the seaweed tastes. Do you like it?

Cooked seaweed

Describe how the seaweed looks. Consider shape, colour, etc.

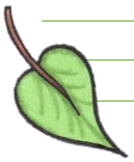
Describe how the seaweed tastes. Do you like it?

Fried seaweed

Describe how the seaweed looks. Consider shape, colour, etc.

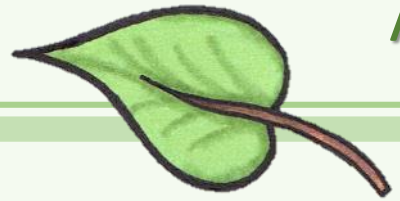
Describe how the seaweed tastes. Do you like it? Does it remind you of some popular food?

Do you think that seaweed can be an alternative, Biobased food source in the future? Why?

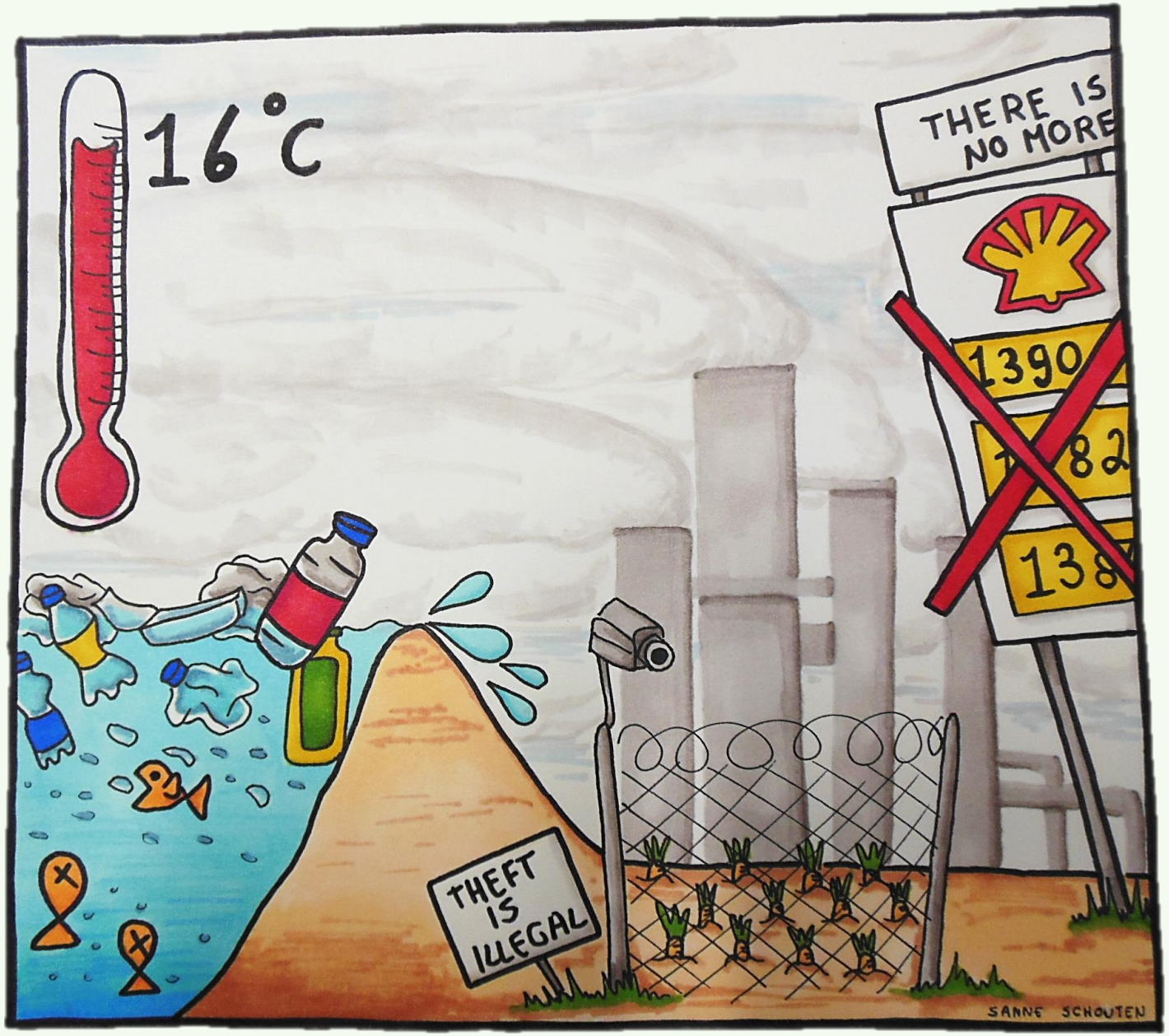


The world in 50 years from now

A Biobased economy



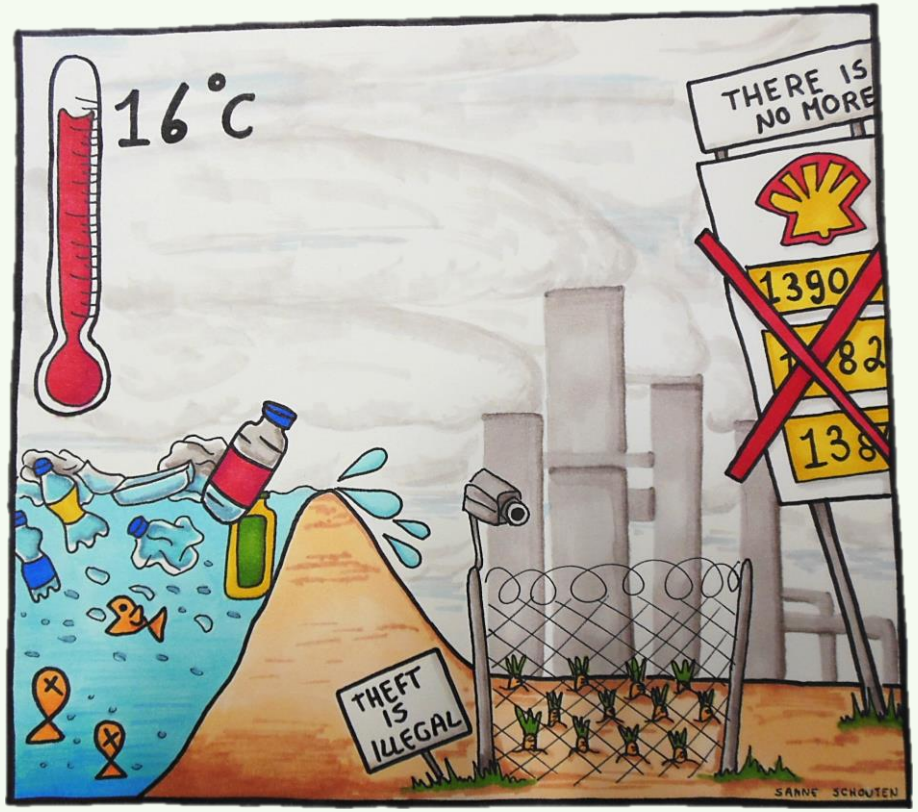
The world in 50 years from now...doing nothing



The world in 50 years from now...in a Biobased economy

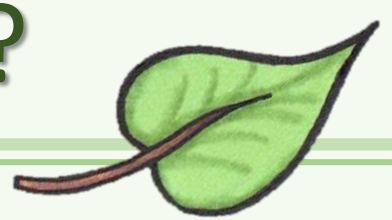
Class discussion

What problems do you see?



The illustrations are also in your workbook!

What is a Biobased economy?



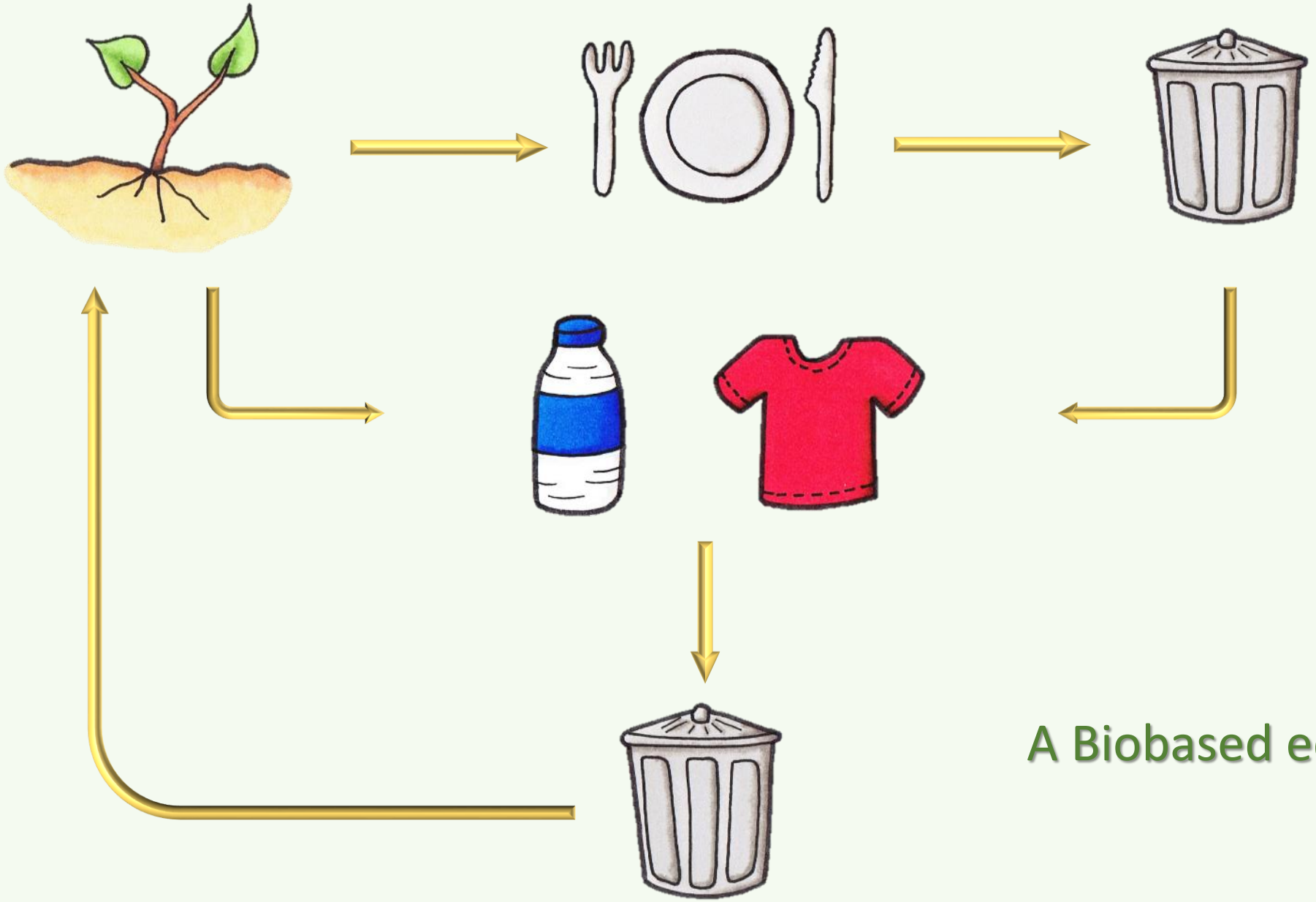
Our economy at the moment…

Fossil fuels

PICTURES BY SANNE SCHOUTEN

Sustainability

We must provide for our own needs,
but must thereby make sure that
the future generations can do the same.



Compost

A Biobased economy

PICTURES BY SANNE SCHOUTEN

Some Biobased applications

Recipe

Ingredients:

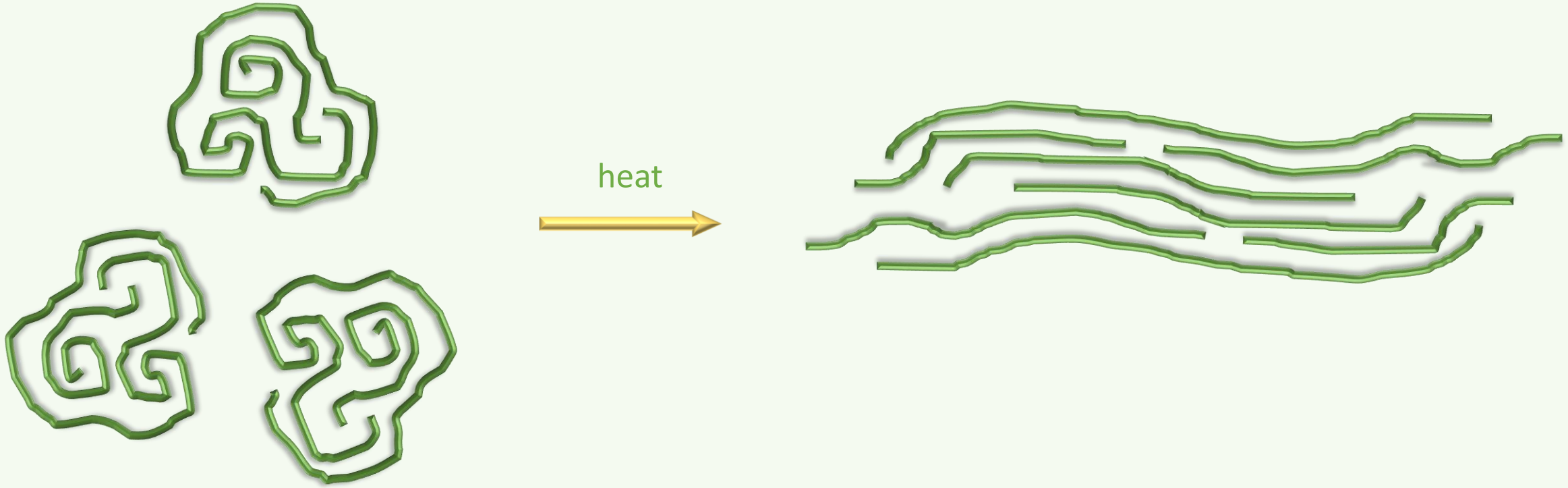
1 pound locusts
7 tablespoons soy sauce
2 cups sake
2 cups sugar
1 cup mirin

Steps:

1. Boil the insects for 1 minute and drain in cold water.
2. Tear off the legs, which are tough and hard to chew.
3. Put locusts in a deep pan or wok and stir-fry them, around 10 minutes, or until all moisture is gone.
4. Pour in soy sauce, sake and sugar, mix well, and simmer for 2 hours, or until all moisture is gone and the locusts are candied.
5. Reduce until insects are dry, then add mirin and stir well to keep it from burning.
6. Turn off heat and serve in a bowl.

RECIPE AND PICTURE FROM: ILYASHOC, 2018

Plastic from potatoes



Seaweed

Sunscreen

Cosmetics

Biobased colours

Bio-plastic

Salt substitute

Fertilizer

Flavouring

Bio-fuel

Let’s test it!

Experiment time!

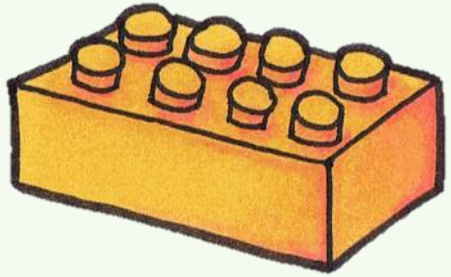
Get involved in the research of finding a new Biobased food source!

All the information you need for the experiment can be found in your workbook!

PICTURES BY SANNE SCHOUTEN

The Maillard reaction

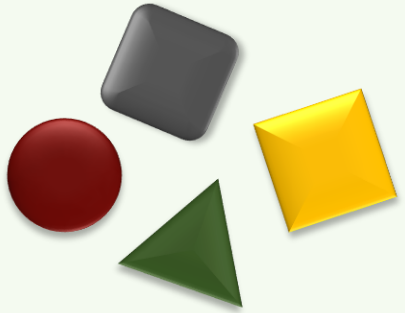
Sugar



Amino acid
(building block of proteins)

Intermediate product

Amadori product



Flavouring and colouring molecules

PICTURES BY SANNE SCHOUTEN

It’s up to you what that world will be like…